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Evaluating the Effects of Radiation from Cell Towers and High Tension Power Lines on Inhabitants of Buildings in Ota, Ogun State

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Abstract: Our Telecommunications industry in Nigeria has been revolutionized by the advent of mobile phone technology. This technology comes with the siting and erection of cell towers in urban centers around the country which is beginning to generate public concern as to whether the utilization of such technology is safe to human health. A case study of the effect of a cell tower with respect to buildings in Ota was done; the power densities of electromagnetic radiation on buildings around the cell tower were calculated. The calculated values were then compared with radiation norms adopted in Nigeria and other countries after which inferences were drawn. Also, the magnetic fields on buildings around the high tension transmission lines were obtained through the inverse square law and by direct measurement using a gauss meter. The results were found to exceed the safe radiation level of 0.4μT using the European standard. Possible solution to ameliorate these ill effects was proffered.

Key words: cell tower, transmission line, radiation, power density, buildings, Ota.

1.0 INTRODUCTION

For several decades high voltage power lines, once suspected of being a cause of childhood leukemia and other illnesses have driven down property values and scared homeowners into fearing for their health(EPA, 1990). Subsequent research has shown the link between power lines and physical ailments, and those who live near these lines are exposed to the effects. Most mobile phone users enjoy the benefits of the technology without giving adequate attention to the health implications of these phones.

Most members of the public are not aware of hazards associated with mobile phones, high tension power lines and cell tower radiations which are harmful due to electromagnetic radiation (EMR) exposure. The numbers of cell phones and cell towers are increasing without giving due attention to its hazards to the society. In recent times, there has been global debate about whether there are health risks associated with radiation from cell phones, high tension power lines and cell towers.

A cell phone transmits 1 to 2 Watt of power in the frequency range of 824 - 849 MHz (CDMA),

890 - 915 MHz (GSM900) and 1710 – 1780 MHz, 1805-1880MHz (GSM1800). In Nigeria, Specific Absorption Rate (SAR) limit for cell phones is 1.6W/Kg which is actually for 6 minutes per day usage (ICNIRP, 1998). It has a safety margin of 3 to 4, so a person should not use cell phone for more than 18 to 24 minutes per day. This information is not commonly known to people in Nigeria, so people use cell phones for more than an hour per day without realizing its associated health hazards. The radio frequency field given off by cell phones and cell phone towers is a type of non-ionizing radiation. It is similar to the type of energy used in AM/FM radio and TV broadcast signals. Unlike ionizing radiation (as emitted by X-ray machines), RF energy from cell phones and other wireless devices cannot break chemical bonds in your body. Cell phones emit low-levels of radiofrequency (RF) energy, some of which is absorbed into the body. The amount of radio frequency energy absorbed depends on many factors such as the

closeness of the cell phone to the body and the strength of the signal. Cell phones are designed to operate at the minimum power necessary to connect and maintain a quality call. Cell phones send and receive radio signals from a network of fixed low-power cell phone towers (or base stations). These towers are usually located on rooftops, towers and utility poles. The transmitting power of a cell phone varies, depending on the type of network and its distance from the cell phone tower. The power generally increases the further one moves away from the nearest cell phone tower.

A base station and its transmitting power are designed in such a way that mobile phones should be able to transmit and receive enough signal for proper communication up to a few kilometers. Majority of these towers are mounted near the residential and office buildings to provide good mobile phone coverage to the users. These cell towers transmit radiation every second, so people living within tens of meters from the tower will receive 10,000 to 10,000,000 times stronger signal than required for mobile communication. Buildings located at certain distances from cell towers are found to absorb high power densities which are dangerous to humans. This paper is therefore meant to determine the effects of electromagnetic radiation on inhabitants' health around cell towers, high tension power lines and also proffering solutions on the reduction of such effects. The epidemiological evidence on magnetic fields and childhood leukaemia relates primarily to exposure in the home. The doubling of childhood leukaemia risk associated with magnetic field exposures above 0.4μT refers to the so-called time-weighted average exposure.[Draper G.J et al 2005]. In fact, there are a variety of ways to characterize exposure to power-frequency magnetic fields, for example the average night-time exposure or the maximum day-time exposure, and the issue of which exposure metric or metrics are most relevant to health risk has been discussed for some time. However new science and electricity supplying authorities claim that electromagnetic radiations from power lines do not interfere with bio-electrical life process and therefore are not to blame for causing diseases like cancer and

premature aging (Linet M.S et al., 1997). Alternative research reveals that both the new science and electricity supplying authorities are misguided in their views. However, it is an established fact that a magnetic field is produced whenever an electric current flows and that the larger the current, the higher the magnetic field produced (Huss A. et al., 2009).

2.0 LITERATURE REVIEW

Mobile phone radiation and health concerns have been raised, especially following the enormous increase in the use of wireless mobile telephony throughout the world mobile phone use EMR in the microwave range and some believe this may be harmful to human health (Huss A. et al., 2009; Binhi V.N et al., 2002). These concerns have induced a large body of research (both epidemiological and experimental, in non-humans animals as well as in humans (Fews A.P et al., 1999) likewise other digital wireless systems, power lines and towers. There are publications which supports the existence of complex biological effects of weaker non-thermal EMF (SAGE Report, 2011; Manlanyi M. et al., 2010). Very strong radiation can induce current capable of delivering an electrical shock to persons and animals. It can also overload and destroy electrical equipment. The induction of currents by oscillating magnetic fields is also the way in which solar storms disrupt the operation of electrical electronic systems, causing damage to and even the explosion of power distribution transformer to (IEEE Standard, 2005) blackouts as occurred in the U.K in 1989 and interference with EMF signals (IEEE Standard, 2005; Aalto et al., 2006) .

Extremely high power electromagnetic radiation can cause electric currents strong enough to create sparks when an induced voltage exceeds the breakdown voltage of the surrounding medium for example, air. These sparks can then ignite flammable materials or gasses, possibly leading to an explosion. It is referred to as Hazard of electromagnetic radiation Ordinance. (HERO). Furthermore, new properties have been

built and continue to be built close to, and under existing power lines. This is may be permitted, providing statutory safety clearances are maintained. It is believed that the majority and probably the large majority of homes which are now underneath or very close to high-voltage overhead lines were built after the line was constructed. There is no statutory obligation on the developer or planning authority to consult with electricity companies in determining planning applications. One area of contention in the past has been attempts by local authorities to prevent development close to lines, or EMF grounds, by means of policies in Development Plans. National Grid or other electricity companies have sometimes opposed such attempts for buildings to encroach into power lines through the use of legal representation at inquiries.

Touching or standing around an antenna while a high-power transmitter is in operation can cause severe burns as obtainable in microwaves (Delgado J.M et al., 1982; Masaki Kouzai et al., 2009). Laboratory experiments have shown that short-term exposure to high levels of RF radiation(100-200 mW/cm^2) can cause cataracts in rabbits (Park R.L, 2002). The study of animals and epidemiology in humans attest to the fact that long term exposure to high-level of microwaves, can cause cataracts (Park R.L, 2002., ICNIRP, 1998). This is why welders wear tinted glass. Two areas of the body the eyes and the testes, can be particularly susceptible to heating by RF energy because of the relative lack of available blood flow to dissipate the excessive heat load. Temporary sterility, caused by such effects as changes in sperm count and in sperm motility, is possible after exposure of the testes to high-level RF radiation.

The UK department of health set up the stakeholder advisory group on extremely low frequency EMFs(SAGE report, 2011) to explore the implications and make recommendations for a precautionary approach to power ,density, frequency, electric and magnetic fields in light of any evidence of a link between EMF and childhood leukemia. The first interim assessment of this report reveals that the link between proximity to power lines and childhood leukemia was sufficient to warrant a

precautionary recommendation including an option to lay new power lines underground where possible and to prevent erecting of new residential buildings within 60m(197 ft) of existing power lines. A 2009 study at the University of Basel in Switzerland found that intermittent (but not continuous) exposure of human cells to a 50Hz EMF at a flux density of 1T or 10G) induced a slight but significant increase of DNA fragmentation in the comet asset (Cleaver J.E, 2000). However that level of exposure is already above current established safety exposure limits.

The Belgian government on their (website) recently said new regulations will soon apply for sales of mobile phones especially for children under seven years of age. The intension is to raise awareness among mobile phone users on health hazards associated with electromagnetic radiations.

Although several literatures confirm that radiation at high levels over a period of time affect people living around radiation sources such as cell towers, transmission power lines and so on. However, one salient point is that the buildings are first overwhelmed by high levels of radiation before the inhabitants fall victims of its hazards. (Ahlbom A. et al., 2001) argued that it is not just fields above 0.4μT that matters but in homes where the average field over 24hrs is greater than 0.4 μT.

2.1 RADIATION NORMS IN DIFFERENT COUNTRIES

In India, radiation norms adopted as given by ICNIRP guidelines of 1998 for safe power density of f/200, where frequency (f) is in MHz. Hence, for GSM900 transmitting band (935-960MHz), .and power density is 4.7W/m2 and for GSM1800 transmitting band (1810-1880 MHz), it is 9.2W/m^2. The ICNIRP guidelines clearly state that for simultaneous exposure to multiple frequency fields, the sum of all the radiation must be taken into consideration. Many countries in the world have adopted much stricter maximum radiation density values of 0.001 to 0.24 W/ m^2 (1/100th to 1/1000th of ICNIRP guidelines) as shown in Table 1. The people in these countries have studied

extensively the health hazards of cell tower radiation on buildings around the area to adopt stricter radiation norms.

Table 1: International radiation limits for different countries (ICNIRP, 1998)

Power Density (W/m²)	**International Exposure limits adopted by various countries**
10	FCC (USA) OET-65, Public Exposure Guidelines at 1800 MHz
9.2	ICNIRP and EU recommendation 1998 – Adopted in India
3	Canada (Safety Code 6, 1997)
2	Australia
1.2	Belgium (ex Wallonia)
0.5	New Zealand
0.24	Exposure limit in CSSR, Belgium, Luxembourg
0.1	Exposure limit in Poland, China, Italy , Paris
0.095	Exposure limit in Italy in areas with duration > 4hours
0.095	Exposure limit in Switzerland
0.09	ECOLOG 1998 (Germany*) Precaution recommendation only*
0.025	Exposure limit in Italy in sensitive areas
0.02	Exposure limit in Russia (since 1970), Bulgaria, Hungary
0.001	"Precautionary limit" in Austria, Salzburg City only

Plate 1: A photograph of the cell tower considered at 2/3 Sam Balogun street, Ota.

Plate 2: A photograph of the cell tower considered.

3.0 METHODOLOGY

Radiation density in buildings around the cell tower was measured with the aid of a power meter, after which the microwave power absorbed by inhabitants within a building was obtained. The exposure time of inhabitants to radiation was then estimated. The magnetic field levels due to radiation from transmission lines at various distances were obtained by taking measurements using the gauss-meter. It should be noted that various distances were determined with the aid of a tape rule.

3.1 ESTIMATION OF RADIATION DENSITY ON BUILDINGS AROUND THE CELL TOWER

Fourteen houses around the cell tower were considered for this research and their distances to the tower obtained with the aid of a tape rule. Distance of houses around the cell tower were 2m, 3m, 4m, 5m, 8m, 12m, 18m, 23m, 27m, 32m, 37m, 43m, 48m and 50m. The general expression of power density according to(D.M Pozar,) is

$$\text{POWER DENSITY } (P_d) = \left\{ \frac{P_t \times G_t}{4\pi r^2} \right\}$$

Where Pd= Power density in watt/m^2

Pt =Transmitter power in watts

Gt= Gain of transmitting antenna

r= Distance from the antenna in meters

The power density of radiation on buildings is the power dissipated per area from the cell tower within the building vicinity. The equipment used to determine the transmitted power of the cell tower is the power meter while the gain of the antenna was obtained from the mast engineer. Considering a building at a distance of 2m from the cell tower, a gain of 50 or 17dB,

If distance(r)= 2m, power transmitted(Pt)=20watts, antenna gain(Gt)=50,

$$Pd = \left\{ \frac{20 \times 50}{4\pi \times 4} \right\} = 19.90 \text{ watt/m}^2$$

the power density from a distance of 2m away from the antenna equals 19.9watt/m^2.

The other values obtained are presented below in table 2.

Table2: Power densities generated in buildings against their distances

BUILDING DISTANCE(m)	POWER DENSITY(watt/m^2)
2.0	19.90
3.0	8.840
4.0	4.970
5.0	3.180
8.0	1.240
12.0	0.550
18.0	0.250
23.0	0.150
27.0	0.110
32.0	0.080
37.0	0.060
43.0	0.040
48.0	0.035
50.0	0.032

Considering standard power densities from 0.001watt/m^2 to 0.24watt/m^2 inclusive adopted by many countries as well as Nigeria as indicated in Table 1. It therefore follows that all the houses with power densities greater than 0.24watt/m^2 are at the risk of suffering from radiation hazards. Also from table 2 above, houses at distances from 2m to 18m are liable to suffer from radiation hazard.

3.2 ESTIMATION OF POWER ABSORBED BY A HUMAN BODY IN A BUILDING

The microwave power absorbed by human body in a building if exposed to cell tower radiation is calculated by modeling a human body as a cylinder(this is done to determine the curved surface area of the body),

Curved Surface Area of a cylinder (CSA)= $2\pi r$ x height ,

Assuming the human waist is taken as $2\pi r$

The curved surface area of a human body = waist x height

If the height = 1.524m and the waist=0.889m therefore,

Curved surface area of a human body(CSA) = 0.889 x 1.524= 1.513m^2

Power absorbed by human body= Pd x CSA= 19.9 x 1.513=30.1 watts

To convert this power to decibel(dB)= 10 log(power)= 10 log(30.1)=14.79dB

Different powers absorbed are obtained at different distances with the human body area constant and shown in table 3 below.

Table 3: Microwave power absorbed by human body against building distances

DISTANCE(m)	POWER ABSORBED (watts)	POWER ABSORBED(dB)
2.0	30.100	14.79
3.0	13.370	11.26
4.0	7.520	8.76
5.0	4.810	6.82
8.0	1.880	2.73
12.0	0.830	-0.80
18.0	0.380	-4.22
23.0	0.230	-6.44
27.0	0.170	-7.79
32.0	0.120	-9.17
37.0	0.090	-10.42
43.0	0.060	-12.18
48.0	0.050	-12.76
50.0	0.048	-13.15

The calculated values of power in watts and decibels of different buildings at different distances corroborate the values obtained directly using the power meter equipment. Table 3 above shows that as the distances of buildings increase, the power absorbed in

such buildings decreases which are clear evidence that close buildings to the cell tower have greater risk of radiation hazard than the ones afar.

3.3 ESTIMATION OF DURATION A HUMAN BODY IS EXPOSED TO RADIATION PER DAY

Microwave energy absorbed by the human body within a given period of time= Power absorbed (watts) x time (sec).

If the power absorbed as calculated earlier=30.1 watts and time is 1hr (3600secs)

Microwave energy absorbed by human body= 30.1 x 3600=108,360 watts-sec

In a day (24hrs), microwave energy absorbed by human body= 108,360 x 24=2,600,640watts-sec.

Using a microwave Power rating of 500 watts, the exposure time of the human body to radiation= microwave energy/power rating=2600640/500=5201.28 seconds

It therefore follows that in minutes, the energy will be=5201.28 / 60=86.69

Table 3 below gives the duration at which human body is exposed to radiation per day at various distances from a cell tower.

Table 4: Duration of radiation exposure against distance

DISTANCE(m)	DURATION(minutes per day)
2.0	86.690
3.0	38.510
4.0	21.660
5.0	13.850
8.0	5.410
12.0	2.390
18.0	1.090
23.0	0.660
27.0	0.490
32.0	0.350
37.0	0.260
43.0	0.170
48.0	0.140
50.0	0.138

Table 4, above reveals that a body 2m away from a microwave source (cell tower) of 500watts of power is subjected to 86.690 minutes exposure in a day. The table further shows that the duration of exposure of human body to radiation decreases further away from the source of radiation.

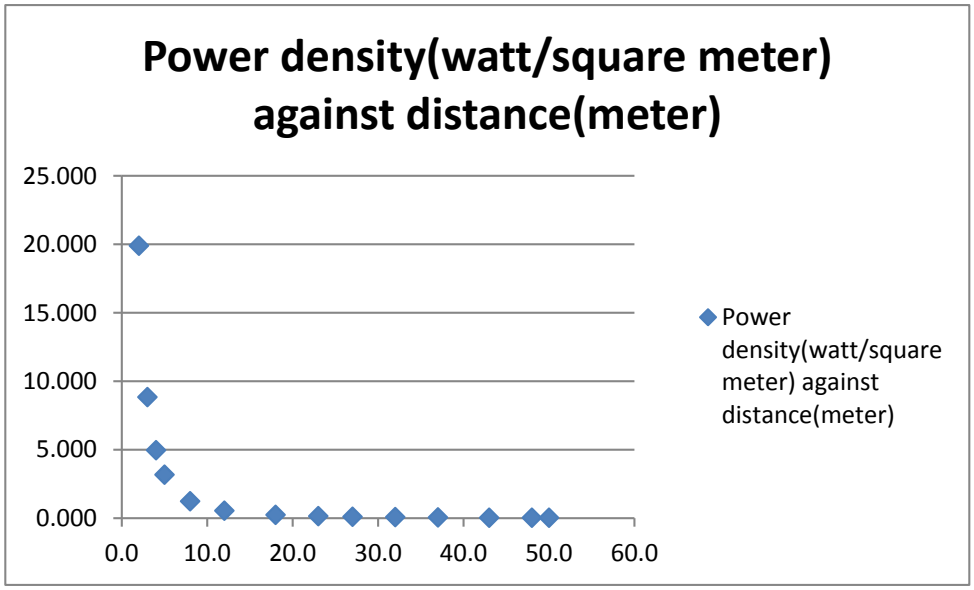

Figure 1: A graph of power density against distance from table 1

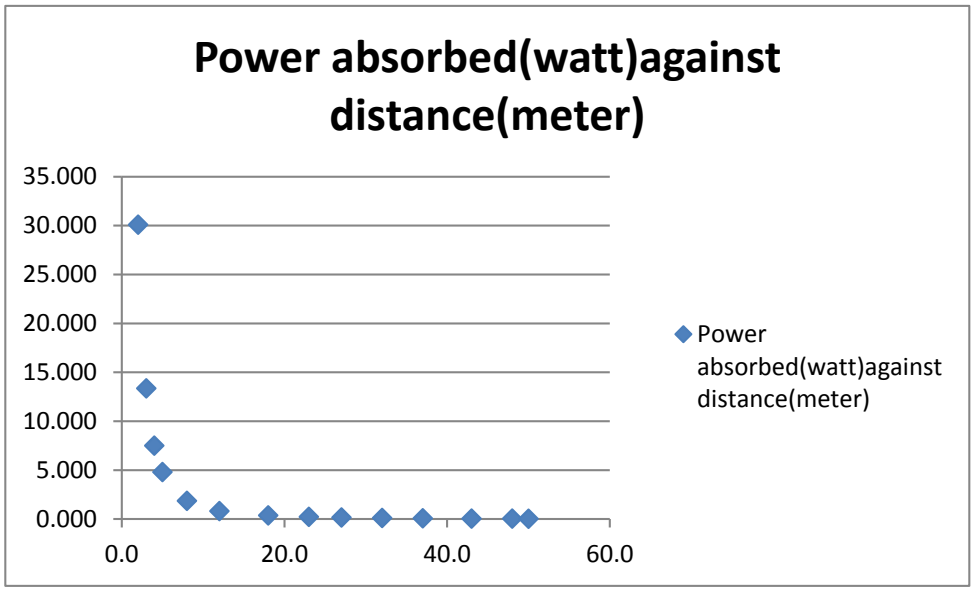

Figure 2: A graph of power absorbed against distance from table 2

3.4 FOR HIGH TENSION POWER LINE OF 132KV

Six buildings around the high tension power line were considered with distances 2m, 4m, 6m, 8m, 10m and 12m.Magnetic fields were taken from residential buildings and undeveloped sites along a 132kv power lines with the aid of gauss meter at mid-day.

Table 5: MAGNETIC FIELDS OF RESIDENTIAL BUILDINGS AND UNDEVELOPED SITE AT DIFFERENT DISTANCES FROM POWER LINES

DISTANCE FROM HT LINE(m)	FIELD LEVEL(mG)	FIELD LEVEL(μT)
2.0 (residential building)	10.5	1.05
4.0 (residential building)	8.2	0.82
6.0 (residential building)	7.3	0.73
8.0 (undeveloped site)	6.4	0.64
10.0 (undeveloped site)	5.2	0.52
12.0 (undeveloped site)	4.1	0.41

Table 5, above reveals that all buildings considered within distances 12m away from the source stand the risk of high radiations which are greater 0.4μT adopted by ICNIRP.

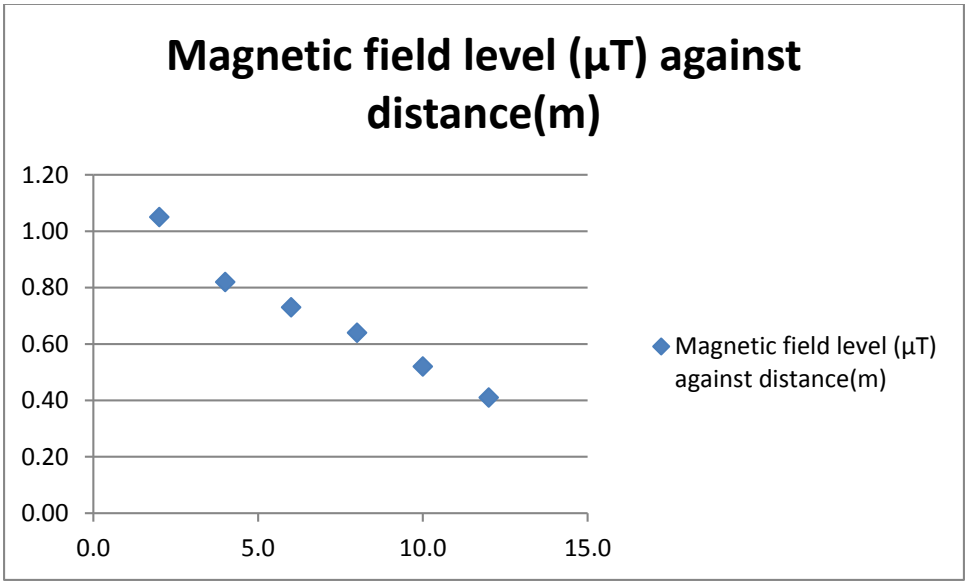

Figure 3: magnetic field level against distance

The graph shown in figure 3 reveals that magnetic field level is inversely proportional to distance of high tension power lines from the location .This means a building located at a very far location from a high tension line will have a low and bearable field.

3.5 INTERVIEWS FROM BUILDING RESIDENTS

Interviews were conducted for ten residents in which five live close to a cell tower and the other five live close to a high tension power lines. Their responses are statistically represented below however five of the responses are shown below.

Feeling violently sick all the time-I relocated a few years ago to my present residence in Ota.

And I've fallen ill regularly and my doctor said it is due to high radiation from the mast located beside my building. I'm already thinking of moving away from my owned apartment very soon.

Me and My wife, Ota

A high tension line runs close to my home in Ota, a few years ago I was diagnosed with cancer, and in the last two years my wife has been lying critically ill.

Bimbo stopped opening her windows for fresh air: I moved into my new house five years ago, which was adjacent to a cell tower structure." I started having headache that is not ordinary. My nerves are strained and I felt unbearable pains. I became insomniac and gets up in the morning feeling tired and uneasy''. The test carried out by her doctor reveals that she is suffering from high level of radiation.

Hassan's explanation: We have lived in this environment for many years and we never had health problems until this GSM people began erecting their mast around us and we discovered a lot of people living within this area began to feel sick. The number of cancer cases has increased, even my father fell victim and died last year.

Obi has extreme difficulty with sleeping: "I had many health challenges when I was younger and I later discovered it was due to high level of radiation from high tension power lines and the feeling of the air pressure around this area is too heavy".

Table 6: General response from interview

Hazard	Hazard experienced	Hazard not experienced
Number	7	3
Percent(%)	70	30

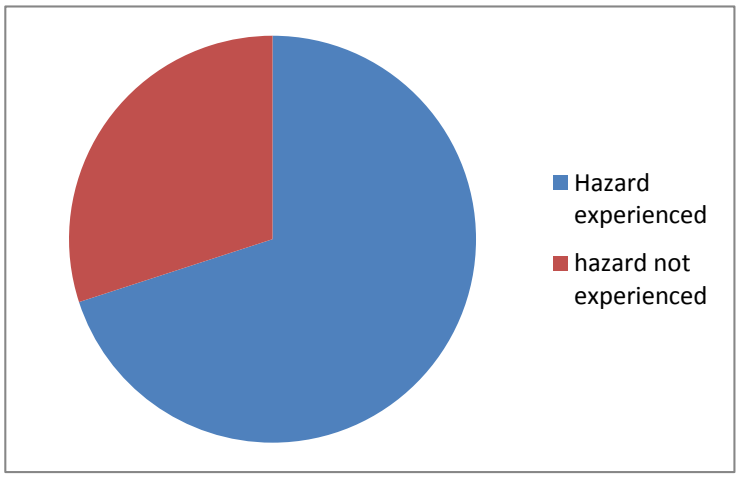

Table 6 and the Pie chart above reveal that 70% of the people interviewed responded by saying they experience hazards which are suspected to have been caused by high radiation levels while the 30% did not affirm to have experienced hazards related to high radiation levels within their homes.

4.0 CONCLUSION AND RECOMMENDATION

The Power and Gauss meters used were able to determine the power densities and the magnetic field levels on inhabitants in buildings within given distances respectively. The readings obtained from the Power meter aid in the calculation of microwave power absorbed by a human body and the exposure time of inhabitants to radiation. The study shows that the absorbed power calculated in watts of different homes at different distances corroborate the values obtained directly using the power meter equipment. It further shows that people who live close to radiation sources are more susceptible to the risk. Also, the outcome of the study shows a high level of compliance of the ICNIRP guidelines since the radiation levels obtained exceed accepted safe level of magnetic field of 0.4μT and 0.024w/m^2 for power density thereby causing different health hazards to inhabitants. It is imperative to note that the public should be sensitized on the dangers of radiations to the citizens and the society at large. The regulatory authorities should enforce strict adherence to safety standards of operation. Town planners and other relevant agencies should take cognizance of this knowledge.

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Abbreviations and Acronyms

SAGE	Stakeholders advisory group on ELF EMFs
ELF	Extremely low frequency
RF	Radio frequency
EMR	Electromagnetic radiation
CDMA	Code division multiple access
SAR	Specific absorption ratio
GSM	Global system for mobile communication
EMF	Electromagnetic frequency
AM	Amplitude modulation
FM	Frequency modulation
DNA	de-oxyribonucleic acid
ICNIRP	International commission for non-ionizing radiation protection
EPA	Environmental protection act
IEEE	Institution of electrical and electronics engineers
TV	television
μT	Micro tesla
`G	gauss
Hz	Hertz
W	watt